PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Satoshi TATSUURA, Yasuhiro SATO, Minquan TIAN and Lyong Sun PU

Prior Group Art Unit: 1741

Application No.: Rule 53(b) Divisional Application of U.S. Application No. 09/571,864

Prior Examiner: E. Wong

Filed: February 26, 2002

Docket No.: 106200.01

For: METHOD FOR ELECTRODEPOSITED FILM FORMATION, METHOD FOR ELECTRODE FORMATION, AND APPARATUS FOR ELECTRODEPOSITED FILM FORMATION

PRELIMINARY AMENDMENT

Director of the U.S. Patent and Trademark Office
Washington, D. C. 20231

Sir:

Prior to initial examination, please amend the above-identified application as follows:

IN THE SPECIFICATION:

Page 2, lines 3-12, delete current paragraph and insert therefor:

The above-cited specification of the U.S. Patent No. 4,349,583, for example, discloses a case of non-electrolytic plating. Referring to this prior art, Fig. 13 illustrates a case in which a less noble metal (LNM) substrate disposed in a plating bath is irradiated with a laser beam LB and a more noble metal (MNM) electrode is formed by metal-plating over the LNM substrate, while Fig. 14 shows an instance in which an LNM film over a glass substrate G is irradiated with the laser beam LB and an MNM electrode is formed by metal-plating over the LNM film.

Page 5, lines 5-6, delete current paragraph and insert therefor:

Figs. 1A to 1B illustrate the principle of a method for electrode formation according to the invention;

Page 5, lines 7-8, delete current paragraph and insert therefor:

Figs. 2A to 2B illustrate a method for electrode formation using a nanosecond laser.

Page 8, lines 2-10, delete current paragraph and insert therefor:

In this mode of carrying out the invention, an object to be treated 10 formed of a glass substrate 11 over which an electroconductive thin film 12 is formed by, for instance, vapor deposition as illustrated in Figs. 1A to 1B is soaked in an electrolyte solution and, in a state in which a bias voltage is applied by an electrochemical method so that an electric current flow at least to the electroconductive thin film 12, the electroconductive thin film 12 is irradiated with a femtosecond laser.

Page 11, lines 9-11, delete current paragraph and insert therefor:

Figs. 1A to 1B illustrate the principle of taking out hot electrons with a femtosecond laser fs whose pulse width is less than a picosecond.

Page 11, lines 12-16, delete current paragraph and insert therefor:

In Fig. 1A, the object to be treated 10, which is to undergo plating, includes the glass substrate 11 over whose surface is vapor-deposited the electroconductive thin film 12. As stated above, this object to be treated 10 is soaked in the electrolyte solution 22.

Page 11, line 17-page 12, line 1, delete current paragraph and insert therefor:

As shown in Fig. 1A, when the surface of the electroconductive thin film 12 of the object to be treated 10 is irradiated with a femtosecond laser, as the femtosecond laser has a powerful electric field in the order of tens of GW/cm^2, the electron temperature in the electroconductive thin film 12 is raised steeply. Then, as the electrons and the grid take at least a few picoseconds to reach a thermal equilibrium, the grid temperature within the electroconductive thin film 12 does not rise during irradiation with the femtosecond pulse. Therefore, the electron temperature and the grid temperature in the electroconductive thin film 12 remain out of equilibrium during irradiation with this femtosecond pulse.

Page 12, lines 2-11, delete current paragraph and insert therefor:

Thus, before irradiation with the femtosecond laser, the electron temperature represented by a solid line and the grid temperature represented by a dotted line in Fig. 1B are equal because they

are in an equilibrium with each other, but once irradiation with the femtosecond laser begins, the electron temperature steeply rises, the temperature rise being particularly conspicuous toward the surface of the electroconductive thin film 12. The grid temperature does not rise during irradiation with the femtosecond laser, resulting in a non-equilibrium as shown in Fig. 1B.

Page 13, lines 5-8, delete current paragraph and insert therefor:

Next, for the sake of comparison, a case in which a pulse laser beam whose pulse width is approximately a nanosecond (hereinafter to be referred to as a nanosecond laser) will be described with reference to Figs. 2A to 2B.

Page 13, lines 9-17, delete current paragraph and insert therefor:

Where the surface of the electroconductive thin film 12 of the same object to be treated 10 as the aforementioned is irradiated with a nanosecond laser, as the electrons and the grid reach a thermal equilibrium during irradiation with this nanosecond laser, the electrons and the grid are equal in temperature whether before or after irradiation with the nanosecond laser as shown in Fig. 2A, except that the temperatures of both the electrons and the grid are higher after irradiation with the nanosecond laser than before it.

Page 18, line 27-page 19, line 8, delete current paragraph and insert therefor:

The fs laser was condensed to 5 W/cm^2, and the cw laser, to 10^4 W/cm^2 in intensity, and the plating formed in each instance was observed through an intermolecular force microscope (AFM). Examination of spots of 2 μm in height and 50 μm in diameter revealed that, while the aspect ratio in the end part was 1/1 where irradiation was accomplished with a cw laser, the aspect ratio under irradiation with an fs laser was improved to 3/1. This presumably is due to suppression of thermal diffusion by the use of the femtosecond laser.

Page 20, lines 7-13, delete current paragraph and insert therefor:

As described above, this invention enables etching in a high aspect ratio and plating in a high aspect ratio to be accomplished using the same femtosecond laser. Accordingly, in this

embodiment, previously difficult electrode machining can be carried out in addition to maskless patterning and electrode repairing. An example of this electrode machining will be described below with reference to Figs. 11A to 11C and Figs. 12A to 12D.

Page 20, lines 14-15, delete current paragraph and insert therefor:

Figs. 11A to 11C illustrate a process to form sharp-edged metal wiring over an insulator substrate.

Page 21, lines 11-16, delete current paragraph and insert therefor:

This process illustrated in Figs. 11A to 11C represents a significant simplification over masked exposure using a resist, and provides fine electric wiring of high quality having a high aspect ratio. If etching is also accomplished using the femtosecond laser, a serial process can be efficiently accomplished without having to replace the laser.

Page 21, lines 17-18, delete current paragraph and insert therefor:

Next, Figs. 12A to 12D illustrate a three-dimensional electrode machining process using a femtosecond laser.

<u>IN THE CLAIMS</u>:

Please cancel claims 1-4, 10, 13, 15, 17, 19, 22, 25 and 27 without prejudice to or disclaimer of the subject matter contained therein.

Please replace claims 18, 20, 21, 23 and 24 as follows:

18. (Amended) A method for electrode formation according to Claim 5, wherein one of Cu, Pt, Zn or Ni is used as plating metal.

20. (Amended) A method for electrode formation according to Claim 11, wherein one of Au, Cu, Pt or Zn is used as the electrode to be machined.

21. (Amended) A method for electrode formation according to Claim 12, wherein one of Au, Cu, Pt or Zn is used as the electrode to be machined.

23. (Amended) A method for electrode formation according to Claim 6, wherein the plating metal is an aqueous solution having a concentration of 2 to 18% wt.

24. (Amended) A method for electrode formation according to Claim 8, wherein the plating metal is an aqueous solution having a concentration of 2 to 18% wt.

REMARKS

Claims 5-9, 11, 12, 14, 16, 18, 20, 21, 23, 24, 26 and 28-31 are pending. By this Preliminary Amendment, claims 1-4, 10, 13, 15, 17, 19, 22, 25 and 27 are canceled and claims 18, 20, 21, 23 and 24 are amended. Prompt and favorable examination on the merits is respectfully requested.

The attached Appendix includes marked-up copies of each rewritten paragraph (37 C.F.R. §1.121(b)(1)(iii)) and claim (37 C.F.R. §1.121(c)(1)(ii)).

Respectfully submitted,

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Date: February 26, 2002

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APPENDIX

Changes to Specification:

The following are marked-up versions of the amended paragraphs:

Page 2, lines 3-12:

The above-cited specification of the U.S. Patent No. 4,349,583, for example, discloses a case of non-electrolytic plating. Referring to this prior art, Fig. 13 illustrates a case in which a less noble metal (LNM) substrate disposed in a plating bath is irradiated with a laser beam LB and a more noble metal ~~(MNH)~~ (MNM) electrode is formed by metal-plating over the LNM substrate, while Fig. 14 shows an instance in which an LNM film over a glass substrate G is irradiated with the laser beam LB and an MNM electrode is formed by metal-plating over the LNM film.

Page 5, lines 5-6:

~~Fig. 1 illustrates~~ Figs. 1A to 1B illustrate the principle of a method for electrode formation according to the invention;

Page 5, lines 7-8:

~~Fig. 2 illustrates~~ Figs. 2A to 2B illustrate a method for electrode formation using a nanosecond laser.

Page 8, lines 2-10:

In this mode of carrying out the invention, an object to be treated 10 formed of a glass substrate 11 over which an electroconductive thin film 12 is formed by, for instance, vapor deposition as illustrated in ~~Fig. 1~~ Figs. 1A to 1B is soaked in an electrolyte solution and, in a state in which a bias voltage is applied by an electrochemical method so that an electric current flow at least to the electroconductive thin film 12, ~~and~~ the electroconductive thin film 12 is irradiated with a femtosecond laser.

Page 11, lines 9-11:

~~Fig. 1 illustrates~~Figs. 1A to 1B illustrate the principle of taking out hot electrons with a femtosecond laser fs whose pulse width is less than a picosecond.

Page 11, lines 12-16:

In Fig. ~~1~~1A, the object to be treated 10, which is to undergo plating, includes the glass substrate 11 over whose surface is vapor-deposited the electroconductive thin film 12. As stated above, this object to be treated 10 is soaked in the electrolyte solution 22.

Page 11, line 17-page 12, line 1:

As shown in Fig. ~~1~~1A, when the surface of the electroconductive thin film 12 of the object to be treated 10 is irradiated with a femtosecond laser, as the femtosecond laser has a powerful electric field in the order of tens of GW/cm^2, the electron temperature in the electroconductive thin film 12 is raised steeply. Then, as the electrons and the grid take at least a few picoseconds to reach a thermal equilibrium, the grid temperature within the electroconductive thin film 12 does not rise during irradiation with the femtosecond pulse. Therefore, the electron temperature and the grid temperature in the electroconductive thin film 12 remain out of equilibrium during irradiation with this femtosecond pulse.

Page 12, lines 2-11:

Thus, before irradiation with the femtosecond laser, the electron temperature represented by a solid line and the grid temperature represented by a dotted line in ~~the lower part of Fig. 1~~ Fig. 1B are equal because they are in an equilibrium with each other, but once irradiation with the femtosecond laser begins, the electron temperature steeply rises, the temperature rise being particularly conspicuous toward the surface of the electroconductive thin film 12. ~~As t~~The grid temperature does not rise during irradiation with the femtosecond laser, resulting in a non-equilibrium as shown in Fig.~~1~~ 1B.

Page 13, lines 5-8:

Next, for the sake of comparison, a case in which a pulse laser beam whose pulse width is approximately a nanosecond (hereinafter to be referred to as a nanosecond laser) will be described with reference to ~~Fig. 2~~ Figs. 2A to 2B.

Page 13, lines 9-17:

Where the surface of the electroconductive thin film 12 of the same object to be treated 10 as the aforementioned is irradiated with a nanosecond laser ~~ns~~, as the electrons and the grid reach a thermal equilibrium during irradiation with this nanosecond laser ~~ns~~, the electrons and the grid are equal in temperature whether before or after irradiation with the nanosecond laser as shown in Fig. ~~2~~2A, except that the temperatures of both the electrons and the grid are higher after irradiation with the nanosecond laser than before it.

Page 18, line 27-page 19, line 8:

The fs laser was condensed to 5 W/cm^2, and the cw laser, to 10^4 W/cm^2 in intensity, and the plating formed in each instance was observed through an intermolecular force microscope (AFM). Examination of spots of 2 μm in height and 50 μm in diameter revealed that, while the aspect ratio in the end part was 1/1 where irradiation was accomplished with a cw laser, the aspect ratio under irradiation ~~wit~~ with an fs laser was improved to 3/1. This presumably is due to suppression of thermal diffusion by the use of the femtosecond laser.

Page 20, lines 7-13:

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Page 20, lines 14-15:

~~Fig. 11 illustrates~~ Figs. 11A to 11C illustrate a process to form sharp-edged metal wiring over an insulator substrate.

Page 21, lines 11-16:

This process illustrated in ~~Fig. 11~~ Figs. 11A to 11C represents a significant simplification over masked exposure using a resist, and provides fine electric wiring of high quality having a high aspect ratio. If etching is also accomplished using the femtosecond laser, a serial process can be efficiently accomplished without having to replace the laser.

Page 21, lines 17-18:

Next, ~~Fig. 12 illustrates~~ Figs. 12A to 12D illustrate a three-dimensional electrode machining process using a femtosecond laser.

Changes to Claims:

Claims 1-4, 10, 13, 15, 17, 19, 22, 25 and 27 are canceled.

The following are marked-up versions of the amended claims 18, 20, 21, 23 and 24:

18. (Amended) A method for electrode formation~~,~~ according to Claim 5, wherein one of Cu, Pt, Zn ~~and~~ or Ni is used as plating metal.

20. (Amended) A method for electrode formation~~,~~ according to Claim 11, wherein one of Au, Cu, Pt ~~and~~ or Zn is used ~~for~~ as the electrode to be machined.

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23. (Amended) A method for electrode formation~~,~~ according to Claim 6, wherein ~~the concentration of the aqueous solution of~~ the plating metal is an aqueous solution having a concentration of 2 to 18% wt.

24. (Amended) A method for electrode formation~~,~~ according to Claim 8, wherein

~~the concentration of the aqueous solution of~~ the plating metal is an aqueous solution having a concentration of 2 to 18% wt.